The Association of Vitamin D Dietary Intake and Type 2 Diabetes Among African Americans in Central Ohio

By
Sin Nee Ng

The Ohio State University
Department of Human Nutrition
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Project Advisor: Julie A. Kennel, PhD, RD, LD
Director, Dietetic Internship,
Department of Human Sciences

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Abstract

Vitamin D deficiency is recognized as a serious health issue. Studies show vitamin D intake levels among African Americans are below Adequate Intakes (IOM). African Americans have higher incidence of vitamin D deficiency, and are two times more likely to develop Type 2 Diabetes (T2D) compared to other ethnic groups. Studies are inconsistent as to whether vitamin D deficiency is associated with T2D. In this study, we investigated the association of vitamin D dietary intake and T2D diagnosis among African American adults in Central Ohio. We hypothesized that African Americans with T2D have lower vitamin D intake levels, and thereby, higher risk of vitamin D deficiency, compared with those who do not have T2D. In this cross-sectional study, we recruited participants (n=8 with T2D; n=15 without T2D) from the Total Health and Wellness Clinic at The Ohio State University Hospital East. We used diagnosis data from the medical record to confirm T2D diagnosis (present/not present). Participants provided their dietary intake through short food frequency questionnaire to obtain vitamin D intake (IU/day). Other measures included serum 25-hydroxyvitamin D (nmol/L), serum fasting glucose (mg/dL), HbA1C (%), used of nutritional supplements and medications, history of medical diagnoses, and sunlight exposure. We used unpaired t-tests to detect differences in vitamin D intake among those with and without T2D. Our results suggest that African Americans at a primary care clinic in Central Ohio with T2D tend to have lower vitamin D dietary intakes compared with people without T2D. All African Americans in our sample, regardless of diabetes diagnosis, reported extremely low dietary intake with an average intake of just 23% of the recommended RDA. Results from this study could be used to determine the need for nutrition intervention for African Americans with or at risk for T2D.

Introduction

Diabetes mellitus has become a significant global health problem among the nation nowadays. There are 347 million people in the worldwide suffering from diabetes and 90% of those people are with type 2 diabetes (T2D).[1] In the United States, 25.8 million of children and adults, which account for 8.3% of the population, are having diabetes. In addition to that, 79 million of the people are identified as pre-diabetes.[2] The prevalence of diabetes is growing dramatically with an increased risk of life-threatening complications, and certain populations, especially African American minority group, experience an even greater threat. There are 4.9 million, or 18.7% of all African Americans aged 20 years or above are diagnosed with diabetes. Compared to non-Hispanic whites, African Americans are 1.8 times more likely to have diabetes.[3] An estimated 3.4 million people died from the complication of diabetes in year 2004, and it is subjected to be the 7th leading cause of death in 2030.[1]

There is a large amount of evidence suggesting that vitamin D deficiency could be a contributing factor that leads to the development of type 1 and type 2 diabetes. Research found that vitamin D plays an imperative role in the normal function of pancreatic islet, as the pancreas contains vitamin D receptors that respond to the active form of $1,25(OH)_2D$[4]. In in vivo and in vitro studies, vitamin D deficiency impaired insulin secretion from β cell and increased the risk of diabetes mellitus[5], whereas vitamin D supplementation restored insulin secretion with improved β-cell function, insulin sensitivity, and attenuated the rise of hemoglobin A1C.[6] On one hand, vitamin D has direct effect on insulin action by stimulating insulin receptor to enhance insulin responsiveness to glucose transport.[7] This effect is further supported by the presence of vitamin D response element in human insulin gene promoter[8] and the transcriptional activation of human insulin gene modulated by $1,25(OH)_2D$[9]. On the other hand, an indirect effect of vitamin D on pancreatic β cell is mediated through the regulation of calcium that has effect on insulin secretion.[7]

Vitamin D has been linked with skeletal health traditionally; however, there has been a recent growth in research that discovered vitamin D's involvement in other body system as well. The modern history of vitamin D traced back to the mid-1800s, when it was found that city children were more prone to rickets than rural children.[10] One and a half century later, Cedric Garland and Frank Garland of Johns Hopkins University hypothesized that exposure to ultraviolet B (UVB) radiation is associated with increased risk of developing colon cancer, while vitamin D and calcium could function to prevent the cancer in humans.[10] Later, studies found that the active form of vitamin D, $1,25(OH)_2D$ produced by kidney interacts with its nuclear receptor, called vitamin D receptor, in the intestine and bone to regulate calcium and bone metabolism.[11,12] Most tissues and cells in the body, including heart, stomach, pancreas, brain, skin, gonads and activated T and B lymphocytes also contain vitamin D receptors that have enzymatic reaction with $1,25(OH)_2D$. Thus, it is not surprising that vitamin D has a noncalcemic function in the human body.[13] In other words, vitamin D status is also associated with other medial conditions, such as cancer prevention, heart disease treatment, and most interestingly, it can improve glucose tolerance and may prevent or treat diabetes mellitus.[14] This cross-sectional study was aimed at investigating the relation of vitamin D dietary intake and type 2 diabetes among African Americans.

Literature Review

Vitamin D, also known as the "sunshine vitamin", is not technically a vitamin and it is not an essential dietary component; rather it is a group of fat-soluble pro-hormone that has molecular structure similar to that of classic steroid hormones.[15] The precursor of vitamin D synthesis is the photochemical production of 7-dehydrocholesterol (provitamin D_3) in the skin.[15] The two main common forms of vitamin D are ergocalciferol (vitamin D_2) and cholecalciferol (Vitamin D_3).[7] Vitamin D_2 is synthesized by plants (mainly mushroom and yeast), while vitamin D_3 is derived both endogenously through the exposure of ultraviolet B

light from sunlight and exogenously from animal food sources such as fatty fish and fish liver oils.[7, 16] Both vitamin D_2 and vitamin D_3 can be made synthetically and are commonly used to fortify foods such as milk products, margarine, and to make dietary supplements.[7,17]

Vitamin D from sun exposure, food, and supplements are biologically inert and require two obligate hydroxylations in the liver and kidney for activation.[18, 19] The first hydroxylation occurs in the liver where vitamin D is converted to 25-hydroxyvitamin D [25(OH)D], also known as calcidiol.[19, 20] The second hydroxylation occurs in the kidney and forms 1,25-dihydroxyvitamin D [$1,25(OH)_2$ D], also known as calcitriol, which needs to bind to vitamin D receptors in order to perform biological actions.[19,20] Serum concentration of 25(OH)D is the best indicator of vitamin D status obtained from cutaneous synthesis and total foods and supplements intake.[16,21] Thus, 25(OH)D may function as a biomarker of exposure that examines the intake level of vitamin D plus exposure to sunlight and reflects the supply of vitamin D to the body.[11] However, it is not clear to what extend 25(OH)D also serves as a biomarker to predict health outcomes.[11] $1,25(OH)_2$ D is not used in this case as an indicator of vitamin D status due to its short half-life and its formation does not directly regulated by vitamin D intake, but parathyroid hormone.[11]

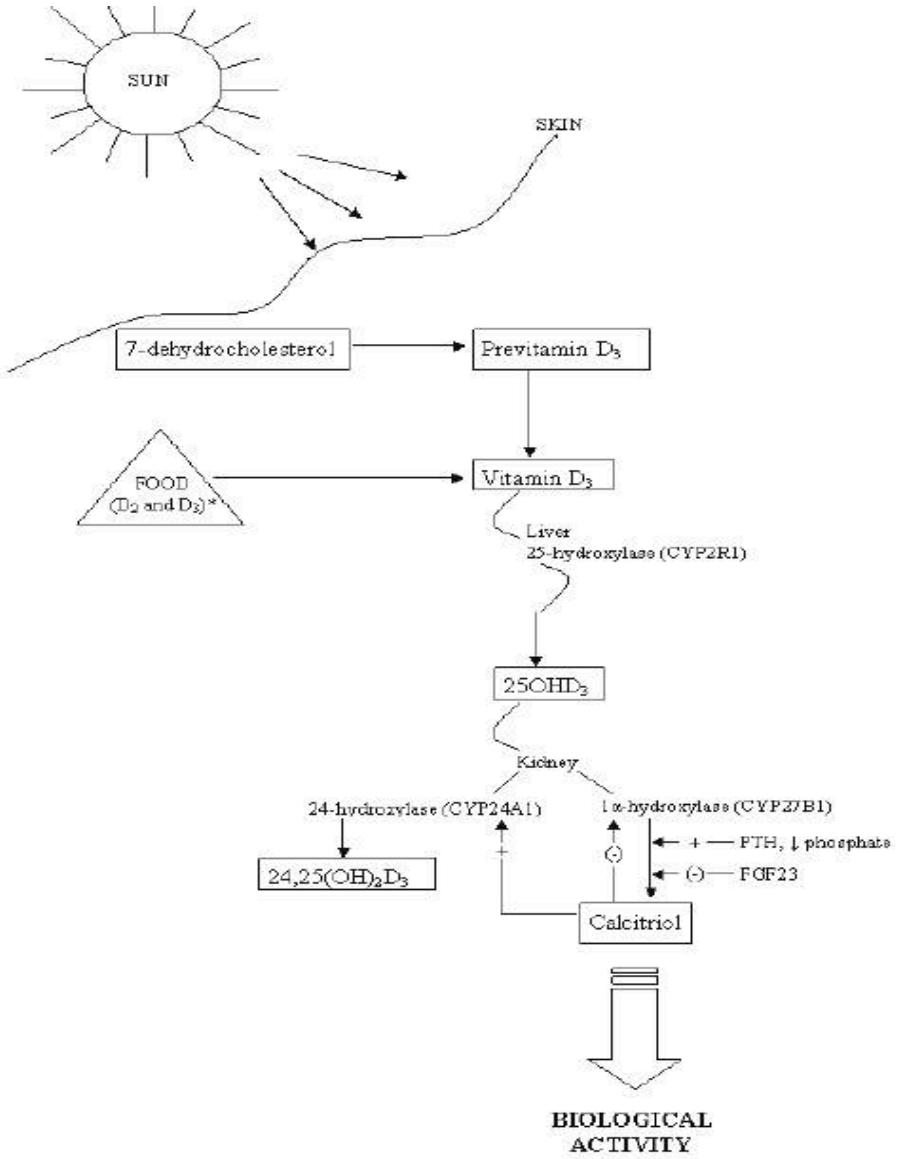


Figure 1: Overview of Vitamin D synthesis, intake, and activation.[9]

According to the US Institute of Medicine (IOM), serum 25(OH)D ≥ 20ng/mL is adequate to cover the needs of 97.5% of the population.[16] Unfortunately, it is difficult to obtain adequate amount of vitamin D from food sources alone.[11] Vitamin D has been taken for granted as the "sunshine vitamin", until recently, when vitamin D deficiency (serum 25(OH)D < 12ng/mL) has been recognized as an epidemic in the United States, especially among African Americans.[11,22] There are many factors that affect serum 25(OH)D levels, including limited synthesis of vitamin D from the sunlight due to the usage of sunscreens, darker skin pigmentation, the effect of latitude and seasons.[11] Other factors that may as well influence serum 25(OH)D level and cause vitamin D deficiency include dietary inadequacy especially those who are lactose intolerant, impaired absorption due to diseases and adiposity, and African American ethnicity.[11]

Sunlight exposure is the major source of cutaneous synthesis of vitamin D and can be affected under different circumstances, including the use of sunscreen, latitude, and seasonal variation.[11] Sunscreens, which absorb the ultraviolet B (UVB) radiation and prevent it from reaching the skin, suppress cutaneous vitamin D synthesis.[23] A sunscreen with a sun protection factor (SPF) of 15 absorbs 99% of the incident UVB radiation, which directly reduces the synthesis of vitamin D in the skin by 99%.[24] In the meanwhile, melanin is a skin pigment found in organisms that acts as a natural sunscreen to protect skin from UVB radiation damage. This skin pigment will compete with 7-dehydrocholesterol for UVB photons and limit vitamin D synthesis.[25] Therefore, people with greater amount of melanin in their epidermis, i.e. African Americans, are less efficient in producing vitamin D than the whites.[25] For the factor of latitude, little serum 25(OH)D is produced from cutaneous synthesis at latitude above 43°N during the winter months between October and March in North America.[11] However, according to the recent data, geographic latitude alone does not consistently predict serum 25(OH)D level in the population. Even in the far north latitude,

there are ample opportunities during spring, summer, and fall months to synthesis vitamin D from sunlight exposure that can be stored in the liver and fat.[26]

Even though foods with fortified vitamin D are available, they are often inadequate to meet either a child's or an adult's vitamin D requirement.[19] Infants and elder adults are the two major groups that are at risk of low vitamin D levels due to inadequate vitamin D intake. Human breast milk alone does not provide infants with adequate intake of vitamin D.[11] Therefore, the American Academy of Pediatrics (AAP) recommends a daily intake of vitamin D of 400IU/day is needed for all breastfed infants.[11] While for older adults, due to aging, their skin cannot synthesize vitamin D as efficiently, and at the same time both men and women experience age-related bone loss that leads to lesser outdoor activities and sunlight exposure.[11] Besides, lactose intolerance are common in older adults, especially African Americans. People with lactose intolerance exclude dairy products (milk, yogurts), which are rich sources of vitamin D; this can be a risk factor for vitamin D deficiency.[11]

Since vitamin D is fat-soluble, its efficient absorption is dependent on the gut's ability to absorb fat. People with inflammatory bowel diseases are prone to fat malabsorption, which significantly reduces absorption of vitamin D.[11] In addition, obesity level is also associated with lowered serum 25(OH)D.[27] Vitamin D is stored in adipose tissue, and thus it could be sequestered in the larger body pool of fat and not released into the circulation in obese people. Due to the sequestration of vitamin D in fat tissue, only little amount of vitamin D is available for the hydroxylation process in the liver of obese individuals compared with non-obese individuals. The decreased bioavailability of vitamin D in obese individuals lead to the consistent observation of lower serum 25(OH)D level.[27]

According to Dong et al. (2013), vitamin D intake during early life is associated with a lower risk of type 1 diabetes (T1D) in which vitamin D has a protective effect against the disease.[9] The beneficial effects of vitamin D involve the regulation of immune system,

including its action in macrophages, monocytes, T and B lymphocytes.[9] Besides the effect on T1D, vitamin D metabolism also plays a potential role in the development of T2D by affecting either insulin sensitivity or β cell function, or both.[5] The research found a positive correlation of serum 25(OH)D concentration with insulin sensitivity and the negative effect of vitamin D deficiency on β cell function.[5] Alternatively, the consumption of vitamin D supplementation might enhance insulin sensitivity and β cell function.[28] A one-year prospective study done by Alkharfy et al. (2013) among adult Saudi patients with or without T2D concluded that vitamin D supplementations in combination with insulin and oral agents therapeutic regimen improved the level of serum 25(OH)D and attenuated the risk of cardiovascular disease among patients with T2D.[28]

While there is an inconsistency in public policy statement between the recommended serum 25(OH)D and vitamin D intake necessary to achieve recommended level, the Institute of Medicine recommends that the adequate intake of vitamin D for children below 12 months is 400IU, whereas adults aged < 70 years and ≥ 70 years required 600IU and 800IU vitamin D/day, respectively.[11] Keith et al. (2011) showed that vitamin D intake levels among African American are below US recommendations, which categorizes the group to have potentially higher risk of T2D.[29] According to Forrest and Stuhldreher's study (2010), vitamin D deficiency is more prevalent among African Americans due to their darker skin pigmentation, different dietary intake patterns, lower education level, and lower socioeconomic status.[30] Therefore, being an African American is one of the risk factors for vitamin D deficiency, which amplifies the risk of T2D. While cause and effect cannot be determined in a cross-sectional study, this project may provide evidence for monitoring and treating vitamin D levels in African American patients at risk for T2D.

Materials and Methods

Objective: The primary goal of this study was to investigate the relation between vitamin D in a person's diet and the diagnosis of Type 2 Diabetes (T2D) among African Americans aged ≥ 18 years old.

Study Design: This study used a cross-sectional research design through a validated food frequency questionnaire and collection of data from medical records (IHIS). A total of 23 participants enrolled in this study in which 8 of them with T2D and 15 of them without T2D. The participants are made up of African American patients from a primary care clinic housed at The Ohio State University Hospital East.

A short screening process was done orally with the participants regarding their age and ethnicity (Appendix B). Any individual who was the patient at the clinic was eligible for the screening. Patients who were screened successfully (either diagnosed with T2D or not) will complete a short food frequency questionnaire (Appendix C) with the researcher in a private room, which last for 10-15 minutes. Only the PI and key personnel will have the access to any documents completed by the participants. The participants' name and identifying information were not included in any publications, and were deleted once the study was completed.

Recruitment: Participants were recruited through personal invitation from the researcher during their clinic visit. In addition, flyers advertisements (Appendix A) were used for recruitment. The flyer stated that the purpose of the study was to investigate the association of vitamin D dietary intake level and T2D diagnosis and that participant would receive a $10 gift card in exchange for their participation.

Evaluation Instrument: The short food frequency questionnaire was derived from the 1992 version of the Block-National Cancer Institute Health Habits and History Questionnaire (HHHQ) and USDA's National Nutrient Database for Standard Reference. Since this study aimed to estimated only dietary intakes of vitamin D, the screening instrument includes only

21 food and beverages listed on the HHHQ and USDA's National Nutrient Database for Standard Reference that contain vitamin D.[31-33] The screening instrument was designed to ask participants how frequently they consume each food or beverage and their usual serving size (Appendix C).

The interview process with the participants included the following questions:

- Are you African American?
- Are you taking any vitamin D supplements?
- How much time did you spend doing outdoor activities during the past summer (June – August)?

Participants' medical records including height, weight, HbA1C, glucose level, serum 25(OH)D level, smoking status, and medical history (diagnoses and medications/ supplements) were assessed through Integrated Health Information System (IHIS) at the clinic.

Statistical Analysis: The statistical analysis estimated the differences in vitamin D dietary intake level between the group with T2D and without T2D as well as potential covariates of age, gender, sunlight exposure, lactose intolerance, glucose, HbA1C, serum 25(OH)D level. Unpaired t-tests were used to determine differences in vitamin D intake levels (dietary only and dietary + supplement). Significance was set at $p < .05$.

Outcome Measures: The following outcomes are the intended measures used to study the association of vitamin D dietary intake and T2D diagnosis among African Americans.

- Average vitamin D values (IU/day) were calculated by using the IU/100g values published in Blalock, Norton, Patel, Cabral, & Thomas (2003)[34] and USDA's National Nutrient Database for Standard Reference[35].
- Participants' T2D diagnosis was confirmed through their medical record assessed from IHIS.

- Average contribution of vitamin D dietary intake from individual food and beverage were calculated by multiplying frequency of consumption by the amount of vitamin D in the food/beverage.
- Serum fasting glucose, HgA1C, and serum 25(OH)D were recorded from the patient's record. The most recent values for each were recorded.

Results

Twenty-three people volunteered to participate in the study. One participant was excluded because researchers were not able to obtain a weight measurement. Table 1 presents the characteristics of study participants by diabetes status. The results showed that the majority of the participants were without diabetes (68.2%), females (50%), age between 21-50 years (59.1%), and all of them were African American. Out of 22 participants, 13 (59%) were obese with a BMI ≥ 30. The participants' mean height, weight, and BMI are shown in Table 1.

Table 1. Characteristics of Study Participants.

	With Type 2 Diabetes N (%)	**Without Type 2 Diabetes N (%)**
Gender:		
Male	2 (9.1%)	4 (18.2%)
Female	5 (22.7%)	11 (50.0%)
Age (y):		
21-50	1 (4.5%)	13 (59.1%)
51-65	6 (27.3%)	2 (9.1%)
Total	7 (31.8%)	15 (68.2%)
	With Type 2 Diabetes (mean ± SD)	**Without Type 2 Diabetes (mean ± SD)**
Average Height (in)	66.7 ± 6.2 **(n=22)**	66.68 ± 2.6 **(n=22)**
Average Weight (lb)	219.6 ± 83.3 **(n=22)**	214.5 ± 68.8 **(n=22)**
Average BMI (kg/m^2)	33.9 ± 8.3 **(n=22)**	33.9 ± 10 **(n=22)**
Sunlight Exposure (minutes/day)	51.4 ± 70.8 **(n=22)**	94 ± 122.6 **(n=22)**
Serum Vitamin D (ng/mL)	17 ± 6.6 **(n=2)**	22.4 ± 10.4 **(n=6)**
HgbA1c	8.4 ± 1.2 **(n=6)**	NA

The average HbA1C level between the participants with T2D (n=7) was 8.4%. No differences were detected in serum 25(OH)D level between the two groups (p=.53). Though those without T2D reported more sunlight exposure, this was not statistically significant (p=.29) (Table 1).

Table 2 shows the mean daily vitamin D intakes as estimated by the HHHQ and USDA's National Nutrient Database for Standard Reference. The average vitamin D foods and beverages intake of participants with T2D was lower than the participants without T2D, but the values were not statistically significant (p=. 34). The average vitamin D and supplementation intake level between groups was not statistically significant (p=. 22) despite the higher values in participants with T2D compared to participants without T2D. None of the participants in this study meet the recommended dietary allowances (RDA) for vitamin D dietary intake of 600IU/day, without supplementation.

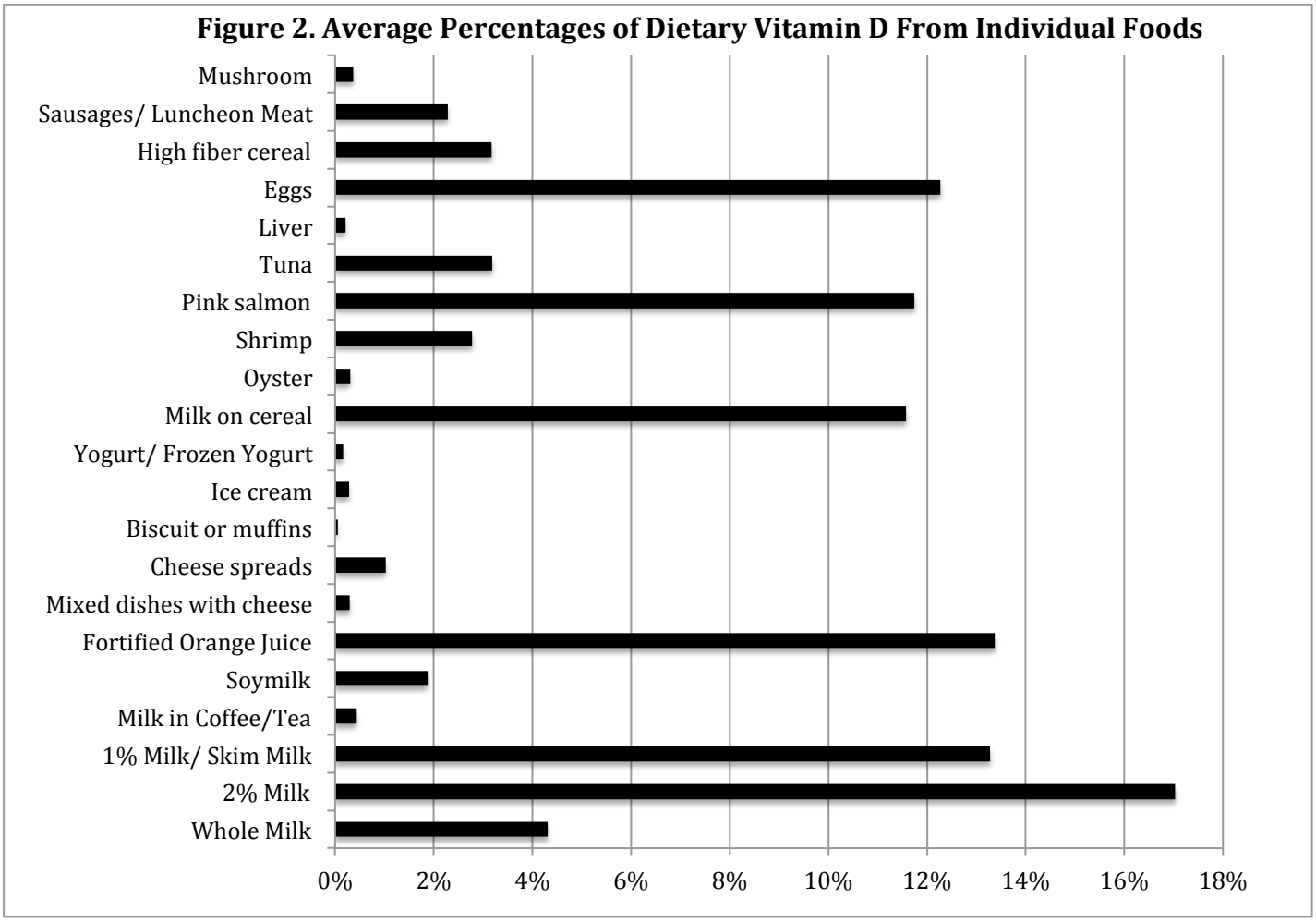
Table 2. Average Daily Vitamin D Intakes (IU/day)

	With Type 2 Diabetes	**Without Type 2 Diabetes**
Average Vitamin D Dietary Intake (IU/day)	98.2 ± 66.8 **(n=7)**	157.0 ± 149.7 **(n=15)**
Average Vitamin D + Supplement Intake (IU/day)*	776.7 ± 1632.9 **(n=6)**	674.1 ± 770.1 **(n=14)**

* Two participants with supplementation higher than 7,000 IU/day were excluded.

Correlation between vitamin D dietary intake level (no supplementation) and the serum 25(OH)D level was found to be $r^2 = 0$. Correlation between vitamin D intake with supplements and the serum 25(OH)D level among participants was $r^2 = .21$.

The percentages of vitamin D contributed by each food and beverage from the participants were listed on the screening instrument as shown in Figure 2. The participants consumed eggs, pink salmon, milk on cereal, fortified orange juice, skim milk, and 2% milk at a higher percentage compared to other foods.



Discussion

While not statistically significant, our findings suggest that African Americans at a primary care clinic in Central Ohio with T2D tend to have lower vitamin D dietary intakes compared with people without T2D, but all African Americans regardless of diabetes diagnosis did not meet dietary recommendations for vitamin D. While there are inconclusive results on the mechanism action of vitamin D in T2D, studies showed that vitamin D play a potential role in regulating glucose transport and insulin secretion in the development of T2D.[5,6]

According to the study by Keith et al. (2011), vitamin D intake levels among African American are below US recommendations (<600IU/day), which was in the same direction with the findings in this study in which participants with and without T2D have an average of

low vitamin D intake of 98.2 ± 66.8 IU/day and 157.0 ± 149.7 IU/day, respectively. The reasons for the statistically insignificant results on the average vitamin D dietary intake level (no supplementation) between the two groups of participants might due to the relatively small number of participants (n=22) in this study. In addition, there was no correlation found between the vitamin D dietary intake level (no supplementation) and the serum 25(OH)D level. A week positive correlation was also found between vitamin D intake with supplements and the serum 25(OH)D level among the participants.

The results (Figure 1) showed that participants in this study consumed a higher percentage of eggs, pink salmon, milk on cereal, fortified orange juice, 1% skim milk, and 2% milk compared to other foods and beverages. 1% skim milk and 2% milk were consumed at a higher percentage over whole milk, because the participants in this study were mainly in the obese category and if not were overweight. The milk supply in the U.S is voluntarily fortified with 100IU/cup of vitamin D; therefore, is a great source of vitamin D. Out of 22 participants, however, ten participants did not consume any milk because they believed they were lactose intolerance. The lactose intolerance status was not documented in their medical records. Participants without T2D consumed higher level of fortified orange juice, because those with T2D were concerned about the high sugar level in the drink. Majority (n=16) of the participants consumed milk on cereal. Pink salmon made up a high percentage mainly due to its high level of vitamin D and was consumed by a number of participants (n=10). Eggs were also a great source of vitamin D that was consumed by majority (n= 18) of the participants.

There are a number of potential limitations in this study. First, the small sample size (n=22) of the study reduces the power to detect significant relationships between the data of the study. Second, there is a large variation in vitamin D supplementation dosage, in which ergocalciferol supplementation contains 50,000 units in one capsule and was consumed once

in a week, while cholecalciferol supplementation contains either 1000 or 2000 units in one tablet and was consumed daily. Third, sun exposure measurement was based on one question, which limits the accuracy. Besides, the measurement was not converted into IU/day and added to the total vitamin D for participants, which might underestimate the vitamin D level of the participants. Lastly, the dietary intake was self-reported; therefore, it is possible that the participants might have over- or underestimated the intake level for each food and beverage.

This study also has some significant strengths. Participants in this study are patients from the clinic and met the target participants all with African American's ethnicity. Besides, it used medical record through IHIS to verify participants' diabetes status. Furthermore, this study used a validated FFQ designed to estimate the usual intake of vitamin D, which provides reasonably accurate estimates of vitamin D intake of the participants.

Conclusion and Implications

In conclusion, we found that participants with T2D have a lower vitamin D intake level compared to participants without T2D. Although the findings were not statistically significant, it may be clinically significant for improving treatment of T2D. In regards to the low vitamin D dietary intakes among the patients, the primary care clinic may wish to provide nutrition education on the importance of vitamin D to all African American patients. In addition, the clinic should make the screening of vitamin D deficiency a necessary procedure for every African American patient in order to prevent any detrimental consequences that are associated with vitamin D deficiency, such as increased risk of having T2D, cardiovascular disease, and cancer[19].

With the growing diabetes mortality rates and increasing healthcare costs for diagnosing and treating the disease, it is essential to confirm the beneficial effects of vitamin D in order to prevent the progression of pre-diabetes to diabetes. If these results are confirmed in prospective studies over a large sample size examining the association between

vitamin D intake level, serum 25(OH)D, and T2D risk or in randomized trials of vitamin D supplementation, they may have important public health implications and provide a simple, effective, and low cost dietary intervention to stem the tide of the increasing rates of diabetes.

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Appendix A.

Volunteers Needed for Vitamin D Study

We need participants for a research study:
"Association of Vitamin D Intake Level and Type 2 Diabetes"

You may ELIGIBLE if you are:

- African American
- Aged 18 or above
- With or Without Type 2 Diabetes

Eligible participant will be asked about the foods they eat.
The study will take about 30 minutes of your time.
You can receive a **$10 gift card** if you participate.

Be part of important Nutrition Research Study!

For more information, please call or email:
Sin Nee Ng (614)-288-0855 or ng.227@osu.edu
or
Julie Kennel (614)-292-3538 or kennel.3@osu.edu

THE OHIO STATE UNIVERSITY

Vitamin D Study (614) 288-0855
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Vitamin D Study (614) 288-0855
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Appendix B.

Oral Script

Hi, I am Sin Nee, an undergraduate student from The Ohio State University. I am currently doing a research study about the association of vitamin D and type 2 diabetes. I am recruiting participants. The study involves asking you questions about what you eat and drink. The time involved is about 10-15 minutes. I will ask you these questions in a private area. Also, I will ask your permission to see your medical record to look at your list of current medications, conditions, and lab results. In exchange for your time, I am offering a $10 gift card.

Are you interested in hearing more about this study?

(Proceed only if answer is yes) Okay, great. First, I will ask you couple questions to make sure you are eligible.
How old are you? (check to verify 18 years of age or older)

Would you describe yourself as African American/Black? (verify answer is yes)

Are you a patient at the Ohio State Total Health & Wellness clinic? (verify answer is yes)

Do you have type 2 diabetes? (answer may be yes or no)

(If answers meet eligibility)
Looks like you are eligible to enroll in our study. I'll walk you through the consent process. (walk through consent with person)

(If answers do not meet eligibility)
You do not meet the criteria for this particular study. I appreciate your time and talking to me.

Appendix C.

Short Food Frequency Questionnaire

This form asks about your usual eating habits over the year.

First: For each food listed, mark the column to show how often, on average, you ate the food during the past year. Please BE CAREFUL which column you put your answer in.

Second: Mark whether your usual serving size is small, medium, or large. Please DO NOT OMIT serving size.

Additional Comments:

- Please DO NOT SKIP any foods. If you never eat a food, mark "Never or less than once per month."
- A small serving is one-half the medium serving size shown or less.
- A large serving is about one-and-a-half times the medium serving size shown or more.

	How Often									How Much			
Type of Beverage	Never or Less than Once per Month	1-3 per Month	1 per Week	2-4 per Week	5-6 per Week	1 per Day	2-3 per Day	4-5 per Day	6+ per Day	Medium Serving	Your Serving Size		
											S	**M**	**L**
Whole milk and beverages with whole milk (not including on cereal)										8 oz glass			
2% milk and beverages with 2% milk (not including on cereal)										8 oz glass			
Skim milk, 1% milk, or buttermilk (not including on cereal)										8 oz glass			
Milk in coffee or tea										1 tablespoon			
Soymilk										8 oz glass			
Fortified Orange Juice										8 oz glass			

	How Often									How Much			
Type of Food	Never or Less than Once per Month	1 per Month	2-3 per Month	1 per Week	2 per Week	3-4 per Week	5-6 per Week	1 per Day	2+ per Day	Medium Serving	Your Serving Size		
											S	**M**	**L**
Mixed dishes with cheese (such as macaroni and cheese)										1 cup			
Cheeses and cheese spreads (including on burgers, tacos, and nachos; not including cottage cheese)										2 slices or 2 oz			
Biscuits or muffins (including fast foods)										1 medium piece			
Ice cream										1 scoop or ½ cup			
Yogurt, frozen yogurt										1 cup			
Milk on cereal										½ cup			
Oysters										6 medium			
Shrimp										3 oz			
Pink salmon										3 oz			
Tuna, tuna salad, tuna casserole										½ cup			
Liver, including chicken livers										4 oz			
Eggs										1 egg = small 2 eggs = medium			
High fiber, bran or granola cereals, shredded wheat										1 medium bowl			
Sausages, luncheon meats (including bologna, salami)										3.5 oz			
Mushroom										1 oz			

Do you take a vitamin D supplement? (if so, list name, dose, and frequency)_____

Appendix D.

Medical Record Intake Form

Patient Assigned Code (from food frequency questionnaire): _____
Age: _____ Gender: _____

Ht: Date Taken:
Wt: Date Taken:

Smoking status:

Current diagnoses:

Evidence of lactose intolerance?

Date diagnosed with Type 2 diabetes:

HgbA1c value:
HbgA1c date:

Markers of insulin resistance:

Current medications and supplements:

Serum Vitamin D level (25-hydroxyvitamin D):
Test Date:

Sunlight Exposure (min/day):